



BioFuels As An Alternative Fuel Source For Aviation



by

Dr. Bilal Mark McDowell Bomani (REB)

Team Members:

Dr. Dan Bulzan – Associate Principle Investigator (RTB)

Robert C. Hendricks (ST-R)

Dr. Bilal Mark McDowell Bomani (REB)

Diana Centeno-Gomez (DEF)

Dr. Arnon Chait (REU)

Dr. Aloysius Hepp (REB)

The sustainability of aviation directly depends on the availability of fuel. With the growing gap between production and demand, increasing prices, and concentration of known reserves in politically unstable regions, biofuels are considered a viable alternative to securing the future of aviation. Biofuels are a renewable energy source, which could be customized to different fuel needs, including jet fuel. NASA GRC has initiated a pilot program to develop in-house capabilities to study two principal sources of biofuels: sea water algae, and arid land halophytes. The present program is focused at putting together the initial infrastructure for the study, to developing a long-term program to study and optimize properties and growth parameters, and to develop collaborations with aviation companies, commercial ventures and government agencies to forward the application of biofuels to aviation needs.



BioFuels As An Alternative Fuel Source For Aviation

The Big at GRC

- (1) We do not use freshwater because it competes with human consumption.**
- (2) We do not compete against traditional food crops such as corn, soybeans, sugarcane, etc...**
- (3) We do not use arable land because it competes with food crops.**

97.5% of the Earth's water is saline
2.5% Freshwater

< 1% of the world's fresh water is accessible for direct human uses



BioFuels As An Alternative Fuel Source For Aviation

Indoor Biofuels Lab



Experimental chambers with various salinity levels



***Chaetomorpha* sp. Macro-Algae**



Soil/Sand planting



BioFuels As An Alternative Fuel Source For Aviation

Indoor Biofuels Lab - Halophytes



Salicornia virginica - Pickleweed



Salicornia europaea - glasswort



Rhizophora mangle - Red mangrove



Kosteletzkya virginica - Seashore mallow



BioFuels As An Alternative Fuel Source For Aviation

- **Developed initial biofuels capability for halophytes, algae, and weeds**
- Indoor laboratory for preliminary feasibility experiments and optimize growth parameters
- **Outdoor greenhouse facility for larger scale, grow-out experiments and small scale open pond system**
- Initiate multidisciplinary modeling project (biology/transport/process) for simulation and optimization of open pond and photobioreactor algae systems.
- **Pursue partnerships with industry, other government agencies, and universities to complement in-house research and for larger scale demonstration and validation**
- SAA with Boeing for biofuels research collaboration



BioFuels As An Alternative Fuel Source For Aviation GreenLab Research Facility



GreenLab Completed in November!!!





BioFuels As An Alternative Fuel Source For Aviation

Optimal Biomass Development

Currently Optimizing for Salinity, Photoperiod, Nutrients and Natural Seeding:

Salicornia virginica, *bigelovii* and *europa* * *Kosteletzkya virginica* * *Chaetomorpha* sp.



Salicornia bigelovii



Salicornia europa



BioFuels As An Alternative Fuel Source For Aviation

Analysis and Processing of BioMass at GRC

•**Oil/Lab Press** : Extract oil by applied pressure



•**Fat Extractor** : Extract lipids from solid sample using a solvent in a batch process.



•**Biofuel GC** : (Gas chromatographer with flame-ionization detection): Analyzes the lipids, specifically the fatty acid content of the extracted oil.



•**Hydrogen Generator/Gas Reactor** : Saturate the unsaturated double (C-H) or triple bonds of the hydrocarbon chains of the fatty acids for processing of the oil.





BioFuels As An Alternative Fuel Source For Aviation

External Collaborations



University collaboration to investigate the use of traditional farming equipment for the cultivating and harvesting of salt-tolerant plants. Large-Scale field trial of *Kosteletzkya virginica* as an ideal plant crop to use for biofuels.

(University of Delaware – Prof. J. Gallagher)

University collaboration to determine ideal growth and yields conditions for *Salicornia* species. Field trial of *Salicornia* sp. in AZ. (University of Arizona – Prof. E. Glenn)

External collaboration to down-select up to 4 salt-tolerant plant species from the VA and FL coastline. Highly successful with propagating three species of *Salicornia* that have the potential to be used for biofuels. (Tropicorium, Inc – D. Perrin)

External collaboration for GreenLab design, setup, maintenance and optimal livestock selection for marine environments. (The Salty Critter – D. Lehky)

Photobioreactor Research

→ Saltwater algae photobioreactor

→ Phase Shifting Polymers

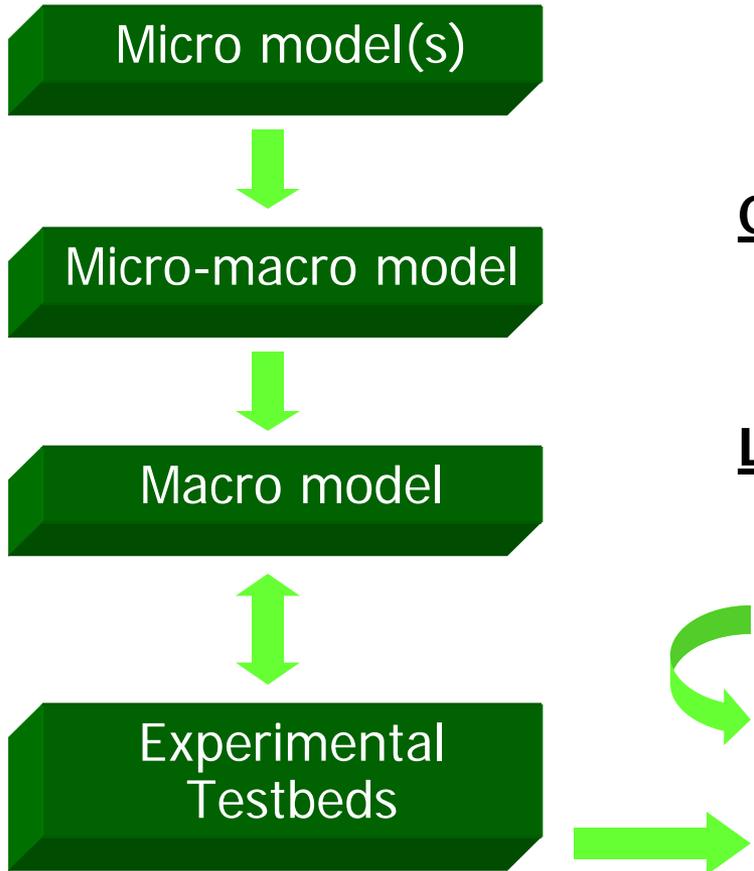
→ Bio-Plastics

→ Hybrid micro-algae systems



BioFuels As An Alternative Fuel Source For Aviation

Open pond system optimization



Basic biology:

- Metabolism, energy conversion, growth, exchange w/environment

Coupling to large-scale transport:

- Distribution function approach

Large scale transport processes:

- Overall geometry, flow, nutrients
- Process optimization





BioFuels As An Alternative Fuel Source For Aviation



by

Dr. Bilal Mark McDowell Bomani (REB)

Team Members:

Dr. Dan Bulzan – Associate Principle Investigator (RTB)

Robert C. Hendricks (ST-R)

Dr. Bilal Mark McDowell Bomani (REB)

Diana Centeno-Gomez (DEF)

Dr. Arnon Chait (REU)

Dr. Aloysius Hepp (REB)

The sustainability of aviation directly depends on the availability of fuel. With the growing gap between production and demand, increasing prices, and concentration of known reserves in politically unstable regions, biofuels are considered a viable alternative to securing the future of aviation. Biofuels are a renewable energy source, which could be customized to different fuel needs, including jet fuel. NASA GRC has initiated a pilot program to develop in-house capabilities to study two principal sources of biofuels: sea water algae, and arid land halophytes. The present program is focused at putting together the initial infrastructure for the study, to developing a long-term program to study and optimize properties and growth parameters, and to develop collaborations with aviation companies, commercial ventures and government agencies to forward the application of biofuels to aviation needs.